

Date	10 February 2026
To	Jon Bright, Project Director – Waitaha Hydro Scheme Westpower Ltd
From	Shelley McMurtrie, EOS Ecology
Project advice provided for	<i>Waitaha Hydro Scheme</i>
Qualifications	Provided to the Panel on 8 August 2026 in Appendix 25: Freshwater Ecology Report ¹
Code of Conduct	Provided to the Panel on 8 August 2026 in Appendix 25: Freshwater Ecology Report
Documents referred to	<ul style="list-style-type: none"> • Waitaha Hydro Power Review of Intake Engineering and Fish Passage (26 January 2026); • Statement of Evidence of Jon Francis Tunnicliffe on River Geomorphology (23 January 2026); and • Substantive Application, Appendix 25: Freshwater Ecology Report
Signature	[Redacted Signature]

1. I have reviewed the peer review reports of Paul Morgan and John Tunnicliffe, and this has not caused me to revise my previous assessment. I address the material concerns raised in my response here.
2. My response to the peer review reports is limited to those matters pertaining to freshwater ecology and fish passage. Matters regarding hydrology, sediment transport, and Project design are covered in the review response from other specialists.

¹ [Appendix 25: Freshwater Ecology](#).

Part 1: Response to the Paul Morgan Review

Review comments pertaining to the level of design detail and specialists required

3. The Morgan review includes a review of the design of the fish passage and other structures at the weir intake area and at the tail race. I do not agree with his assessment and note the following:
- (a) Given my inputs to the development of the proposal; my specific knowledge of the site, wider catchment and its fish populations (including physico-chemical conditions and biological communities); and knowledge of fish and fish passage structures, I am satisfied that kōaro passage at the weir intake and tail race will be achieved and that the proposed conditions are robust in requiring that it is. The relevant conditions are addressed by Mr Jackson in his evidence, and are also summarised in (b) below.
 - (b) The proposed consent conditions include requirements for:
 - (i) the design of the fish passage structure to allow for the passage of kōaro into Kiwi Flat to be maintained whilst salmonids are excluded (Part C9, Condition 9);
 - (ii) the final design of the tail race to involve a range of specialists with relevant experience and expertise (Part C9, Condition 2);
 - (iii) Westpower to seek feedback from DOC on the final design (Part C9, Condition 3).
 - (c) These conditions allow for the final design of the structures to occur at the appropriate time of the Project's design phase. This will ensure that there is sufficient time, detailed design of other inputs, and resources invested in the design of the structure, whilst also requiring that the design meets key criteria and involves a multidisciplinary team of specialists. The current design concept also retains flexibility in the design that will allow for key fish passage considerations to be able to be incorporated into the developed and detailed design phases.
 - (d) The Morgan review reiterates the importance of having "*a suitably experienced and qualified engineer with specific fish passage related skills who is able to develop potential solutions*" in relation to fish passage at the intake and tail race. I agree with this statement, and as noted above, involvement of this expertise during the final intake design is required under Part C9, Condition 2, and in terms of the tail race, this expertise is also required during the final tail race design as set out in the Freshwater Environmental Management Plan (FEMP).²

² Section 4.6

Review comments pertaining to the intake and fish passage at this point

4. The Morgan review considers that it is not possible to build any type of fish passage structure at the intake site that would enable kōaro to negotiate it (i.e., move upstream into Kiwi Flat). I disagree with this statement for the following reasons:
- (a) As addressed by Dr Clunie, the weir is approximately 3 m higher than the current existing rock bar at this point, with a maximum water level differential to the downstream side of the weir of around 5.5 m when the river is only passing the environmental flow of 3.5 m³/s, decreasing to zero as the flow increases as the weir is drowned by the natural choking effect of Morgan Gorge at flows of around 150 cumecs. The current concept design for the downstream side of the weir shows a 1:1 sloped grade. In contrast kōaro are known to be able to scale 60 m high waterfalls (McDowall, 1990; 2003). A fish passage case study by the New Zealand Fish Passage Advisory Group (2020) also found that kōaro were able to negotiate 6-8 m high vertical waterfalls with 0.3-0.5 m horizontal undercuts downstream of culverts, merely with the inclusion of mussel spat ropes and rubber aprons.
 - (b) Kōaro are climbing species – the key criteria for kōaro passage are to maintain damp edges, resting zones, and roughness to support their climbing behaviour. Kōaro do not necessarily seek out and follow the greatest source of flow, with experiments by Magaju et al. (2022) showing that they tend to avoid locations with higher turbulent kinetic energy. They are not obligate water column swimmers like salmonids; kōaro whitebait begin migration into freshwater around 40 mm long and at around 50 mm become negatively buoyant and tend towards a benthic-dwelling behaviour (Rowe & Kusabs, 2007), with flume tank experiments showing them maintaining their position on the tank bottom (Crawford, 2024) presumably supported by the use of their 'hooked'/ridged fins. They preferentially use a damp splash zone to climb a surface; technical guidance on the creation of kōaro passage structures based on testing has shown that flow should be as low as possible/a trickle of water (Franklin et al., 2024).
 - (c) The behaviour and attraction of kōaro to passage structures has not been studied or tested. However, kōaro are more abundant in the small tributaries of the Waitaha River compared to the mainstem, including tributaries that have only a small trickle of water at the confluence point to the Waitaha River; when migrating upstream they have been able to detect these significantly smaller inputs to seek out these tributary habitats. Work by Magaju et al. (2021; 2022) also observed that kōaro would seek out lower water velocities and avoid locations with higher turbulent kinetic energy.
 - (d) Kōaro are also known to burrow into the substrate to enter waterways and springs that otherwise do not have a surface flow, and can burrow through lightly packed material (Rowe & Kusabs, 2007).

- (e) As inland migration is gradual, fish may lose their climbing ability as they grow larger and bulkier. This is the case with other recognised 'climbing' species, such as banded kōkopu, shortjaw kōkopu and tuna/eels. However, kōaro are more likely to retain a greater portion of their climbing ability as adults given their long-thin body shape. As such they are found at the highest elevations (up to 1,200 m altitude) and some of the longest distances inland of any of our migratory fish species. Trials of kōaro passage over a weir have also shown that individuals with a lower length-weight ratio were more successful at navigating the structure (Tabak, 2020).
- (f) The Morgan review states that there has been very limited success in fish passage for any structures with a significant water level difference. I am aware of examples of kōaro passage structures that have been tested and shown to work, as well as barriers designed to exclude kōaro have been shown not to work (i.e., kōaro have still been able to negotiate them). Some of these are summarised in the 2024 version of the NZ Fish Passage Guidelines (Franklin et al., 2024). I agree that there are fewer fish passage structures that have been designed for kōaro specifically, but the absence of structures has less to do with the difficulty to successfully create them and more about the fact that there is less need for the construction of passage structures for excellent climbing species. There has also been some recent work on the swimming and climbing ability of kōaro that will be helpful for the detailed design of the structure (for example, see Crawford et al., 2025; Magaju et al. 2021; 2022; and Tabak, 2020).
- (g) Site specific context for any passage structure is important. The access of kōaro into Kiwi Flat is likely already limited by the challenging flow conditions in Morgan Gorge as well as distance inland. Certainly when comparing the densities of kōaro found in sites in Kiwi Flat to fish density records from the New Zealand Freshwater Database (NZFFD) they were lower than the national average for kōaro densities (mean of 4.4 kōaro/100m² for Kiwi Flat sites vs a mean of 9.6 kōaro/100m²) based on 1,645 records in the NZFFD where kōaro have been recorded and density data is available). Thus the intent is not to improve overall access into Kiwi Flat but to at least maintain it at the current levels. Without the Project the constrained flow through Morgan Gorge would create challenging flow conditions for kōaro, whilst with the Project in place the residual flow through Morgan Gorge may well improve the swimming access of kōaro through the gorge (at times when it is in residual flow), but there will be a passage structure to negotiate at the top of the gorge.
- (h) Monitoring of the kōaro population is also a requirement of the consent, and if monitoring indicates recruitment issues, then there is provision allowing for modifications to be made to the structure. This is described in detail in the FEMP and is discussed further by Mr Jackson in his evidence.

5. The Morgan review considers that the current weir design or passage through the environmental flow gate would risk damage to kōaro moving downstream. I provide further discussion around this matter below:
- (a) As addressed by Dr Clunie, the height of the weir is approximately 3 m higher than the current existing rock bar at this point, with a maximum water level differential to the downstream side of the weir of around 5.5 m when the river is passing the environmental flow of 3.5 m³/s, decreasing to zero as the flow increases as the weir is drowned by the natural choking effect of Morgan Gorge. The current concept design for the downstream side of the weir shows a 1:1 sloped grade.
 - (b) The relatively steep grade change for the river channel as it enters the constricted entrance to Morgan Gorge is described in the responses of Mr McCahon and Dr Hicks.
 - (c) Kōaro populations exist above natural structures that are higher and/or steeper than that proposed by the Project, which means that kōaro in such areas are subject to drops that are more severe than what is proposed here.
 - (d) The downstream movement of kōaro larvae occurs during elevated flows and floods, not base flow conditions – as spawning occurs in flood-inundated substrate in autumn and subsequent hatching is triggered by elevated flows during fresh/flood conditions when the eggs are again inundated and agitated by the flood waters. The height above, and distance from, the base flow water level that spawning occurs is variable, but research on kōaro spawning in Australia has found eggs as far as 7 m away from the base flow channel (O'Connor & Koehn, 1991). The very nature of their spawning strategy relies on high flow events for spawning and egg hatching, with these same flood flows increasing the chances of larvae being washed far downstream to the sea (or lake), where food supply and potential growth rates are higher. In the case of the Kiwi Flat kōaro population specifically, the larvae will hatch and be washed downstream during elevated flows and flood conditions and thus will experience the natural turbulent flow conditions through Morgan Gorge. As such the flood flow conditions that kōaro larvae are exposed to as they are washed downstream will not significantly change with the Project in place, where a large portion of the flood flow will continue to pass through Morgan Gorge via the weir and sluice channel, with the water level differential across these structures diminishing with flow magnitude).
 - (e) Finally, as per Section 3, as the design of the Project continues to be developed it must meet the consent requirements that specify “*a suitably qualified and experienced engineer, a freshwater ecologist and an expert familiar with who to provide advice on the design of the weir and intake structures (including the diversion weir) with the objective to appropriately manage adverse effects on river morphology, sediment transport and*

potential adverse effects on kōaro and whio”). This provides surety that the design process must account for these considerations along with the overall Project design.

6. The Morgan review considers that there is a risk that eels could get into Kiwi Flat and if that happened that this would have an impact on the kōaro population in Kiwi Flat given the limited number of kōaro in the Kiwi Flat area. I disagree with this statement for the following reasons:
- (a) The Waitaha River is an unfavourable/inhospitable habitat for longfin eel:
- (i) the water temperature is below the 11-12 °C temperature when eels remain inactive for extended periods of time (Joy et al. 2013). Based on daily average data from two years of water temperature, the average daily water temperature is between 3–12.3 °C, has a two year median of 6.8 °C, remains below 12 °C for all but one day, below 11 °C for 97% of the year, and below 7 °C for 53% of the year. As water temperature can drastically alter fish physiology and thus their swimming ability (Muhawenimana et al. 2021), not only would such low temperatures interfere with their ability to remain active and to feed, but it would also reduce their swimming performance and ability to negotiate barriers;
 - (ii) the habitat is highly disturbed in relation to stream flow variability (as discussed in Section 11(a)(ii)); and
 - (iii) the food supply is limited (i.e., significantly lower diversity and densities of invertebrates in the mainstem vs tributaries, with an average of 13 taxa/site and 324/m² in the mainstem vs 18 taxa/site and 804/m² in other tributaries and 32 taxa/site and 5,307/m² in stable tributaries).
- (b) During the two years of conventional fish surveys of 48 sites in the Waitaha River mainstem (20 sites) and tributaries (28 sites), only one longfin eel was caught in the mainstem river. For the tributary waterways they were found in eight sites (spanning two stable tributaries and two other tributaries). This system is clearly not an ideal environment for eels and the numbers present in the system that would be available to potentially move into Kiwi Flat would be extremely low.
- (c) In the current environment the absence of longfin eel in Kiwi Flat is based on the challenging flow conditions in Morgan Gorge and the unfavourable/inhospitable environment of the Waitaha River for eels. The inhospitable environment will remain even with the proposed Project in operation, but will also have the addition of a weir at the top of Morgan Gorge.
- (d) However, even if longfin eel somehow did gain access into Kiwi Flat, either in its current state without a hydro Project or following a hydro Project being put in place, I also

disagree that this would have a large impact on the kōaro population in Kiwi Flat. This is because:

- (i) Eel numbers would remain very low due to the overarching abiotic factors limiting the eel fishery in this river (i.e., Section 6(a)-(c) above).
- (ii) The cohabitation of longfin eels and kōaro, and the predation of eels on kōaro, is part of the natural ecosystem - indeed the whitebait run (which includes juvenile kōaro) is considered to be a key marine subsidy for high trophic level fish such as eels (Stewart et al., 2022). The distribution and abundance of kōaro has been negatively correlated with trout but not with eels (Kusabs, 1989), whilst the collapse of (lake dwelling) kōaro populations has only been linked to the introduction of trout or smelt (Rowe & Kusabs, 2007). Reference that is made to eels negatively impacting on other native fish populations in documents such as the New Zealand Fish Passage Guidelines (Franklin et al., 2024) is in reference to non-migratory galaxiid species and non-migratory Canterbury mudfish, rather than migratory galaxiids such as kōaro.
- (iii) The ability for eels to successfully predate on kōaro, or outcompete them for resources, is temperature dependent, as below 11-12 °C eels become inactive for extended periods of time, thereby dramatically reducing their ability to predate on, or compete with, other fish. As set out in Section 6(a)(i) the Waitaha River temperature remains below 11 °C for 97% of the year, and whilst tributary waterways were only spot measured for temperature during sampling in September 2007, the average water temperature of tributaries at that time was 9.4 °C.

7. The Morgan review made some comment regarding survival of kōaro through the intake and turbines (Section 6.1). I provide further discussion on this below.

- (a) The only fish present in the Kiwi Flat area are kōaro. They were primarily found in tributaries rather than the mainstem (four caught in the mainstem at Kiwi Flat vs 141 caught in tributaries). The habitat of the mainstem river is not good habitat for fish given the highly disturbed nature of the system and the low density of invertebrates (i.e., their food supply) in comparison to that found in the tributary waterways (see Section 6(a)(iii) and Section 14(b)). The in-river habitat from Whirling Water downstream to the top of Morgan Gorge is particularly inhospitable, consisting of mainly unstable material and fast water velocity as the upstream bed grades down to the rock platform at the gorge entry (a description of this river section is provided in the response of Mr McCahon and Dr Hicks). As such any kōaro migrating upstream will continue to move upstream in search of inflows that indicate tributary habitats. In my opinion the risk of adult fish being present in the mainstem habitat above the intake and getting washed through the intake structure is low.

This means that the potential for fish going through the intake structure will be primarily limited to kōaro larvae that have hatched and are being washed downstream to the sea.

- (b) Given their small size at hatching (<7 mm) there is general agreement that they would be less likely to be damaged by collisions with boulders or turbine blades (i.e., physical strike), and that the main potential effect would relate to pressure changes. Whilst the development of the swim bladder in kōaro is not well documented, other galaxiid species are physostomes, having an uninflated sac that must be inflated after hatching by gulping/swallowing air. There would be a natural mortality of newly hatched larvae that are unable to inflate their air sac within time (i.e., by the time they reach calmer waters where buoyancy is needed). As kōaro hatch during fresh/flood conditions (see further discussion on this in Section 5(d)) it is probable that many larvae would not be able to inflate their air sac prior to being carried downstream with the flood flows. As such it is probable that there will be kōaro larvae that pass through the tunnel that do and do not have an inflated air sac. It is also recognised that given the turbulent and constrained conditions through Morgan Gorge there would be a natural mortality of kōaro larvae being washed through the gorge.
- (c) Finally, the matters outlined in Section 3(b), 3(c), and 3(d) ensure that the design process must account for kōaro survival considerations along with the overall Project design.

8. The Morgan review made some comments regarding fish screening at the intake. I provide further discussion on this below as it pertains to fish ecology, but note that other experts have also responded to this matter.

- (a) Kōaro length at hatching is around 7 mm in length (McDowall & Suren, 1995; Rowe & Kusabs, 2007). Given their small size and the timing of when they hatch (i.e., during the rising limb of a fresh/flood event as described in Section 5(d)) the larvae would rely on river flood flow currents to wash them downstream, with little ability to swim against the current or choose where to go.
- (b) Kōaro larvae hatch during elevated flows/food events around autumn, as described in Section 5(d). As such it is unlikely that they will be travelling downstream during a time when there is only the environmental flow and water passing through the intake (i.e., at flows <26.5 cumecs), but will instead be moving downstream during times when there is also additional flow travelling down Morgan Gorge.
- (c) Further discussion on the intake screen size and the design as it currently stands is provided in the responses of other experts. But I would also reiterate my statement made in Section 3 above.

Review comments pertaining to the power station tail race and fish passage at this point

9. The Morgan review makes comment about the design of the tail race and the impact on upstream movement of kōaro at this point. I provide further discussion on this below.
 - (a) I refer back to my statement made in Section 3 above.
 - (b) There are a number of key research papers on the swimming and behaviour traits of kōaro that will assist in the design development, and it is my understanding that there remains flexibility in the design of the tail race to allow for consideration of their upstream movement. As such, it remains my opinion that the final design will be able to ensure that not all kōaro moving upstream on this side of the river will become entrained in the tail race.

10. The Morgan review raises concern around the tail race attracting trout and eels and increasing the risk of predation of kōaro whitebait. I do not agree for the following reasons:
 - (a) As discussed above, the Waitaha River mainstem is an inhospitable environment for eels and their densities are particularly low. Similarly, the Waitaha River mainstem from MacGregor Creek upstream is not a good trout fishery for similar reasons of disturbance regime and low flood supply, along with poor visibility for a visual water column-feeding predator. This was borne out by the survey data that showed between 0-7 trout were caught in the seven mainstem river sites downstream of Morgan Gorge in the 'Douglas Creek' reach (equating to 0-1.3 trout/100m²) compared to 0-15 trout caught in tributary waterways from this area (equating to 0-9.5 trout/100m²). As such the number of trout present in the system that would be available to potentially move into the tail race is low.
 - (b) Even given the more stable flow conditions of the tail race, the potential for trout and eels to become a predation pressure or interspecies competition risk for kōaro is unlikely given the low densities of both eels and trout in the river mainstem, and the prevailing low water temperatures which are below the optimal temperatures for both species.
 - (i) The temperature range of the Waitaha River and the lower thermal tolerances of longfin eel has been covered above.
 - (ii) Trout are considered a cold-water species; their growth optima when food supply is not limited is considered to be between 14-17 °C (Hay *et al.*, 2006). Whilst they can survive in water close to 0 °C their metabolic rates and activity drop in colder water; studies have shown that their metabolic rate in 10 °C is significantly lower than in 15 °C and their behaviour and activity becomes sluggish, with fish becoming inactive at very low temperatures. Other studies have shown a reduction in prey capture probability at lower temperatures, with Watz & Piccolo (2010) recording an

approximate halving of prey capture between 14 °C and 5.7 °C, and most of this reduction occurring below 8 °C. Given the temperature of the Waitaha River is below 12 °C 97% of the time and below 6 °C 53% of the time, it is evident that the low temperatures would have an impact on trout activity and feeding. Combined with the low densities of trout in the Waitaha River I do not expect that trout predation or competition pressures would reach an impactful level in this location.

Review comments pertaining to trout use of the abstraction reach and accessing Kiwi Flat

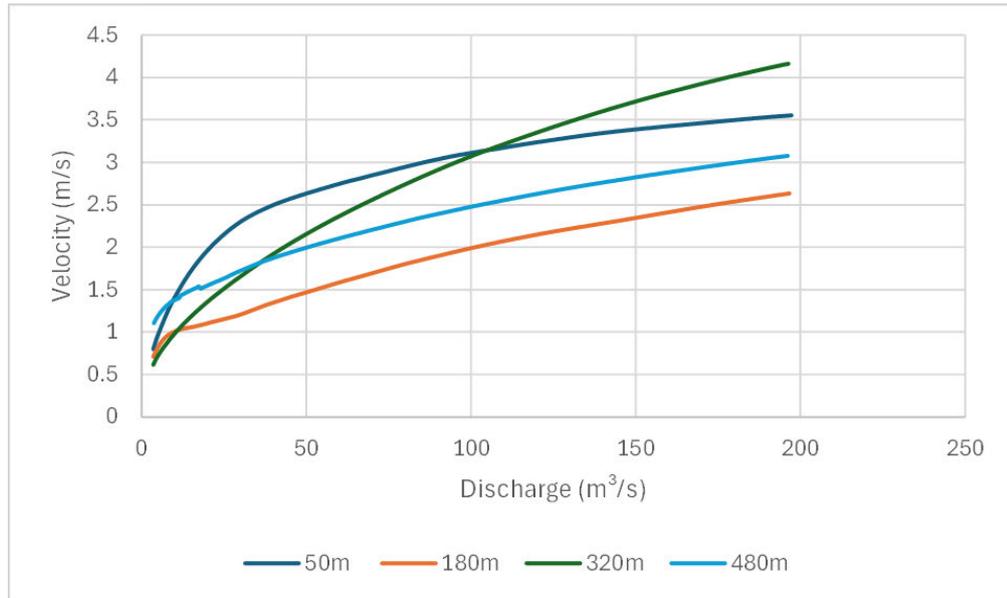
11. The Morgan review considers that the reduced flow may make the abstraction reach more attractive to trout (Section 5.2 of the Morgan review) and whilst Mr Morgan agrees that it is unlikely that trout would then be able to successfully swim upstream through the environmental flow release gate he does consider that trout may be able to move upstream when the intake is drowned out (occurring when the river is at 150 cumecs and higher) (Section 5.4 of the Morgan review). I disagree with these statements for the following reasons:
- (a) For increased passage of trout through the abstraction reach to be a viable risk, there first needs to be fish able to survive in the system, which is contingent on many more factors than just the residual flow conditions.
 - (i) As discussed above, the Waitaha River mainstem is an inhospitable environment for trout and their densities are particularly low (Section 10(a), Section 10(b)(ii)). As such the number of trout present in the system that would be available to potentially move into the abstraction reach is already very low.
 - (ii) Trout presence and abundance in systems is linked to stability; trout are not able to persist in systems that are highly disturbed (Jowett, 1992). The Waitaha river has a natural FRE_3 ³ in relation to stream flow variability and in the upper range for New Zealand rivers (Clausen & Biggs, 1997), and is far in excess of what is considered ideal for trout. The FRE_3 will change slightly to 23.6 once the Project is in operation; meaning that even with a residual flow of 3.5 cumecs, the high level of disturbance will ensure that the river mainstem will remain inhospitable for trout.
 - (iii) Food resources are another factor in considering habitat suitability for trout. As covered in the Freshwater Ecology report, even with the scheme in operation the extremely low nutrient status and continuation of the high disturbance regime means conditions will not favour any increase in the current low invertebrate densities and diversity. Further discussion about the invertebrate community is covered in Section 6(a)(iii) and 14(b) of my response.

³ The typical categories of FRE_3 are generally as follows: Stable systems/low disturbance = $FRE_3 < 10$; moderately stable/intermediate disturbance = $FRE_3 10-15$, unstable/very disturbed = > 15 .

- (b) Notwithstanding the above, the matter of whether trout would be able to access Kiwi Flat when the weir is drowned out (i.e., at around 150 cumecs) is unlikely for the following reasons:
- (i) Based on information from Mr Doyle, there were 28 occurrences over a two year period when flow increased from 26.5 cumecs to 150 cumecs in less than 48 hours. The median time for the flow increase during these events was five hours (the shortest being 1.25 hours and the longest 35 hours). There were also seven flood events that took longer than 48 hours to develop across this flow range and multipeak floods spanning many days when flows did not drop below 50 cumecs. Any trout just downstream of the weir would need to maintain their position during the rising limb of a flood event for many hours until such a time that the weir is submerged, before being able to exploit a submerged weir at the top of Morgan Gorge. Trout within Morgan Gorge would face an even more difficult proposition, as the velocities through the Gorge will remain high and turbulent even once the flow above the gorge is choked.
 - (ii) Based on the work by Bell (1990), brown trout have a 'burst' swimming speed (i.e., able to maintain for a short duration (< 20 seconds)) of 2.44 – 3.96 m/s, a sustained speed (i.e., able to maintain for up to an hour) of 0.67 – 1.92 m/s, and a cruising speed (i.e., able to maintain for long periods of time (hours)) of 0 – 0.67 m/s in ideal conditions (Bell, 1990).⁴
 - (iii) Information from Dr Clunie on modelled flow-velocity at four representative cross-sections within Morgan Gorge (at 50 m, 180 m, 320 m and 480 m downstream from the intake weir) indicates that the average velocity will increase from 0.5 – 1.2 m/s at 3.5 cumecs to 2.4 – 4 m/s at 150 cumecs (also see the figure below). Taking a conservative approach and using the maximum Bell (1990) sustained swimming speed (i.e., able to maintain for up to an hour) of 1.92 m/s, based on the figure below this is exceeded by the time flow reaches 50 cumecs at three of the four modelled distances downstream, and by the time it reaches 100 cumecs at one of them. Whilst these modelled values are an average velocity, which means that there will be areas of slower and faster water velocity, there would not be contiguous pockets of sufficiently slower water velocities through the length of the gorge for trout to take

⁴ Bell (1990) does not specify fish length, but based on the studies that are referred to it is considered likely that trout size was around 150-300 mm.

advantage of.



(iv) Swimming ability of brown trout as published by Bell (1990) is based on 'ideal' conditions. The swimming ability of brown trout is also strongly linked to water temperature, with experiments showing water temperatures of around 16 °C to be optimal for swimming performance and a drop off in swimming performance at temperatures below that (i.e., Ojanguren & Brana, 2000; Taugbol et al., 2018). Concomitantly Watz & Piccolo (2011) showed that there was a significant reduction in prey capture probability at temperatures below 10 °C and also observed that trout would rest on the substrate at temperatures below 8 °C instead of holding their position in the water column despite the low water velocity that was well within their sustained swimming capability. In addition, Pinder & Eales (1969) found that buoyancy of salmonids was reduced at lower temperatures, which would also impact on their energy output to maintain a water column swimming position. Thus it is highly unlikely that the sustained swimming velocities provided in Bell (1990) would be able to be maintained in the colder (less ideal) water temperatures of the Waitaha River (as noted in Section 6(a)(i), the daily average water temperature range in the Waitaha River is 3-12.3 °C, with a two year median of 6.8 °C).

(v) Morgan Gorge is a narrow gorge that will keep flows constricted in any sized event. This means that flow conditions downstream of the weir during a ca. 150 cumec flow event will be extremely turbulent, with large volumes of fine and coarse sediment in suspension. There is nowhere for the flows to spread out into and refuge habitat or areas of slower velocity where trout can rest will likely be limited given the steep-sided walls of the gorge and bedrock polished smooth by the action of water and sediment. This would be an inhospitable environment for any fish.

- (vi) Considering all of these factors I cannot imagine that any brown trout would be able to maintain their position in, or move through, Morgan Gorge during the rising limb of flood events until such a time that the weir was submerged at 150 cumecs and then to swim into Kiwi Flat.
- (vii) This is also reinforced by the fact that to date trout have been unsuccessful in traversing Morgan Gorge during flows of 150 cumecs, when the same choking effects at the top of Morgan Gorge occur in its current state.

Part 2: Response to the Jon Tunncliffe Review

- 12. I have read both the Tunncliffe review and the response by Dr Hicks (as well as Mr McCahon and Dr Clunie). I observed a general agreement in the responses of Hicks, McCahon and Clunie. With the response of Dr Hicks confirming his original effects assessment, I am comfortable that my effects assessment remains the same in relation to matters pertaining to sediment transport effects on biota.
- 13. The Tunncliffe review focuses on the sediment assessment, and as such the response to that review is covered in the response by Dr Hicks (and others). A general concern raised is regarding bedload/sediment needing to be cleared out by mechanical removal. This is explained in detail by others, including the role of the sluice as the primary sediment transfer mechanism. However, from a freshwater ecology perspective I do not see any issues should the sluice gate / channel / intake area become blocked with bedload/sediment. These events are predicted to occur infrequently and will be promptly cleared. However, even if that was not the case, water will continue to flow over the weir structure. Given the climbing abilities of kōaro (as I have extensively addressed above), the height and slope of the weir structure, and the fact that the fish passage structure should be able to be designed to continue to operate (given its current concept placement on the true left side it is away from the side of the river with the sluice gate). As such I do not have concerns in regards to this.
- 14. There is one comment in the Tunncliffe review that recommends establishing invertebrate community monitoring as part of the development of ecologically based thresholds for sediment deposition (paragraph 58 of the Tunncliffe review) and a comment regarding the value of the invertebrate community of the river mainstem to whio (paragraph 15 and 46 of the Tunncliffe review). I provide some commentary regarding these two matters below:
 - (a) A transect-based quantitative invertebrate sampling programme was implemented in 2007 as part of the initial ecological surveys to establish river-specific habitat useability curves of key invertebrate taxa for IFIM modelling as well as to accurately describe the ecological community of the river and its tributaries. For sites in the river mainstem, quantitative

invertebrate samples were collected and habitat measurements recorded across a transect running perpendicular to the bank (i.e., across the channel). Many of these sites (14 of the 20 mainstem sites) were located at the same location as the IFIM transects used by Allen & Hay (2013). Two teams of three personnel worked from opposite banks, sampling from the edge of the channel to the middle of the river, or until the river became too deep or too fast to safely sample – which meant that at 11 of the 20 mainstem sites it was not possible to safely sample across the entirety of the channel (Sites 3, 5-8, 10-12, 15, 19, 20). The number of samples collected ranged between 10 and 14 per site, with the greater number of samples collected at those river sections that were widest. Site locations downstream of Morgan Gorge were primarily dictated by where it was safe to access more than the margins of the channel. Given the challenging environment of the Waitaha River it was simply not possible to implement ‘standardised protocols’, which are primarily developed for wadeable rivers and streams. Samples in deep water (greater than 0.7 m) or fast flow had to be collected using snorkelling gear and heavy dive weights, with an ‘anchorman’ providing additional stability to the weighted snorkeler, which allowed sampling in deeper and faster water than is usually possible using more conventional sampling techniques. Surber sampling techniques were further modified to also provide for rock-rolling and boulder rubbing techniques to account for the bedrock and boulder habitat that forms a key substrate type, especially within the abstraction reach. Whilst the sampling provided a more comprehensive ecological dataset for the river and sampled a greater range of habitats than what would have been possible with more conventional techniques, the sampling was very challenging to undertake (the sampling window within which the flow was sufficiently low to safely access but not within two weeks of a fresh was particularly challenging to achieve). There would need to be a very careful consideration of the viability of repeating such an effort today.

- (b) Notwithstanding the logistical and health and safety challenges of the sampling, the density data obtained is a robust and valuable dataset for which to base discussions on. When comparing the median invertebrate density for the Waitaha River mainstem sites (352 individuals/m²) with that from other West Coast rivers (2,883 individuals/m²) it is evident that invertebrate density in the Waitaha River is considerably lower than other West Coast rivers. There were no significant differences in ordination scores, invertebrate density, taxonomic richness, calculated MCI scores, or the number of EPT taxa between the different reaches of the Waitaha River. The mean invertebrate density throughout the Waitaha River mainstem was 324 individuals/m² of streambed, and while not statistically significantly different, did tend to trend upwards with increasing distance downstream (e.g., from 249/m² in the Upstream Reach to 391/m² in the Downstream Reach). These invertebrate densities were low compared to the mean densities of invertebrates in stable tributaries (mean 5,307/m²) and other tributaries (804/m²) in the catchment. Species

evenness was also particularly low with 80% of total abundance in mainstem sites dominated by *Deleatidium* mayflies and orthoclad midges (Orthoclaadiinae and *Strictocladus*). Thus, in terms of food value for which the tributary waterways, including Whirling Water, Bartrum Creek, and the true-right tributary in the Kiwi Flat area provide far better food resources than the mainstem river.

- (c) Stream disturbance is recognised as the primary abiotic factor regulating stream invertebrate communities in pristine systems (Lancaster, 1996; Winterbourn, 2004). Systems devoid of regular disturbance (e.g., stable streams) typically support a much greater diversity and abundance of invertebrates (Death, 1995; Lancaster, 1996), and in such systems biotic factors (e.g., resource supply, predator-prey interactions) have a significant influence on population dynamics (Peckarsky, 1984; Wootton et al., 1996; McMurtrie, 2000). Flood-prone systems are most influenced by the intensity and frequency of disturbances, which far outweigh biotic interactions such as predation, competition, and resource supply (Peckarsky, 1984; Lancaster, 1996). In such flood-prone systems, the invertebrate community is limited to those taxa that can rapidly colonise or persist in disturbed environments, such as some chironomids and mayflies. According to the Hydrology Report, the Waitaha River has a FRE₃ of 26 (i.e., floods greater than three times the median flow, or >60 cumecs, occurs 26 times a year), which is in the upper range for New Zealand rivers (Clausen & Biggs, 1997). Based on the information provided by the other specialists regarding hydrology and geomorphology, it is my opinion that the invertebrate community will continue to be driven by this overarching disturbance regime and the very limited basal food resources, with the recolonisation of taxa based on their life history traits and distance to source populations along with the time between large bed moving events. I do not consider it would be possible to develop ecological triggers based on invertebrate density data that would be able to adequately distinguish between community changes based on the variable shifts in fine sediment versus larger overarching disturbance regime and food supply factors, or detect any statistically significant change given the otherwise large natural stochasticity of the invertebrate community inhabiting the mainstem river. As such, I do not believe that invertebrate monitoring is appropriate in this situation.

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